# LEVELLING TEST RESULTS

# AND

# THE SPACE FOR LEVELLING COMPROMISE

Prepared by Poland

# LOAD - LEVELLING TEST

*Performed on 13 September 2022 in LTIK Karlsruhe by IWG-SLR*

**Purpose of the test was to check what is precision of automatic levelling system of real cars as the base to verify aiming diagram („box") horizontal size It was measured the relative change of cut-off inclination with respect to the initial setting (set as 0.00%)**

**Testing conditions**
- **5 cars with automatic levelling system manufactured according existing Regulation No 48**
- **No special preparation of car (as they were)**
- **4 different loading conditions from driver only up to maximum back load**
- **Measurements of reaction of automatic levelling to load change**
- **At the end of each test measurements were repeated for the first condition as the check of repeatability**

**TEST SUMMARY**

**Relative change of cut-off inclination (in %) in relations to initial value (0.00%)**

**+ up    - down**

| Vehicle No | 1L(eft) headlamp | 1R(ight) headlamp | 2L | 2R | 3L | 3R | 4L | 4R | 5L | 5R |
|---|---|---|---|---|---|---|---|---|---|---|
| Load condition | | | | | | | | | | |
| 1 | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% |
| Back to 1 | -0,03% | -0,11% | -0,08% | -0,09% | -0,19% | 0,02% | -0,07% | -0,12% | 0,01% | 0,00% |
| 2 | -0,31% | -0,31% | -0,40% | -0,32% | -1,07% | -0,99% | 0,29% | 0,20% | -0,04% | -0,06% |
| 3 | -0,32% | -0,32% | -0,45% | -0,24% | -1,19% | -1,08% | 0,41% | 0,29% | 0,01% | 0,11% |
| 4 | -0,31% | -0,34% | 0,48% | 0,81% | -0,40% | -0,14% | 0,36% | 0,31% | 0,05% | 0,18% |

## RESULTS ANALYSIS

| Vehicle | 1L | 1R | 2L | 2R | 3L | 3R | 4L | 4R | 5L | 5R |
|---|---|---|---|---|---|---|---|---|---|---|
| Load condition | | | | | | | | | | |
| 1 | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% |
| Back to 1 | -0,03% | -0,11% | -0,08% | -0,09% | -0,19% | 0,02% | -0,07% | -0,12% | 0,01% | 0,00% |
| 2 | -0,31% | -0,31% | -0,40% | -0,32% | -1,07% | -0,99% | 0,29% | 0,20% | -0,04% | -0,06% |
| 3 | -0,32% | -0,32% | -0,45% | -0,24% | -1,19% | -1,08% | 0,41% | 0,29% | 0,01% | 0,11% |
| 4 | -0,31% | -0,34% | 0,48% | 0,81% | -0,40% | -0,14% | 0,36% | 0,31% | 0,05% | 0,18% |

- It was checked the returning back to reference value – behaviour of the vehicle and measuring setup repeatability.
- Value depend on precision of vehicle, its positioning on the stand, cut-off shape and sharpness
- Repeatability within 0.1% was obtained except one headlamp
- For the car No 5 the repeatability was 0.01% (perfect !).

# RESULTS ANALYSIS

## Precision of automatic levelling

**For vehicle 1, 4 and 5 system reaction is up to 0,4% in regard to initial value and nearly the same for left and right headlamp.**

| Vehicle | 1L | 1R | 2L | 2R | 3L | 3R | 4L | 4R | 5L | 5R |
|---|---|---|---|---|---|---|---|---|---|---|
| **Load condition** | | | | | | | | | | |
| 1 | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% |
| Back to 1 | -0,03% | -0,11% | -0,08% | -0,09% | -0,19% | 0,02% | -0,07% | -0,12% | 0,01% | 0,00% |
| 2 | -0,31% | -0,31% | -0,40% | -0,32% | -1,07% | -0,99% | 0,29% | 0,20% | -0,04% | -0,06% |
| 3 | -0,32% | -0,32% | -0,45% | -0,24% | -1,19% | -1,08% | 0,41% | 0,29% | 0,01% | 0,11% |
| 4 | -0,31% | -0,34% | 0,48% | 0,81% | -0,40% | -0,14% | 0,36% | 0,31% | 0,05% | 0,18% |

# RESULTS ANALYSIS

System of car No 2 and No 3 are excluded from further analysis:
- Meet existing requirements
- Do not react with expected precision
- Should also meet proposed requirements (<1.2%)
- Unknown technical details of system – no  possibility to check if it is feasible to narrow the range of reaction (after proper calibration ?)

| Vehicle | 1L | 1R | 2L | 2R | 3L | 3R | 4L | 4R | 5L | 5R |
|---|---|---|---|---|---|---|---|---|---|---|
| Load condition | | | | | | | | | | |
| 1 | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% |
| Back to 1 | -0,03% | -0,11% | -0,08% | -0,09% | -0,19% | 0,02% | -0,07% | -0,12% | 0,01% | 0,00% |
| 2 | -0,31% | -0,31% | -0,40% | 0,32% | -1,07% | -0,99% | 0,29% | 0,20% | -0,04% | -0,06% |
| 3 | -0,32% | -0,32% | -0,45% | -0,24% | -1,19% | -1,08% | 0,41% | 0,29% | 0,01% | 0,11% |
| 4 | -0,31% | -0,34% | 0,48% | 0,81% | -0,40% | -0,14% | 0,36% | 0,31% | 0,05% | 0,18% |

# RESULTS ANALYSIS

Control of levelling  by different load:

- Vehicle No 1 - the same value (within 0.1%) for different load  and slightly down (-0.3%), slightly overcompensated, very close values left and right headlamps
- Vehicle No 4 - the value within 0.2%, slightly overcompensated
- Vehicle No 5 -  left within 0.1%, right within 0.2%

System can potentially control aim better than 0.05% (vehicle No 5 L)

For vehicle 1, 4 and 5 total system reaction (as it was) is up to 0,4% in regard to initial value and nearly the same for left and right headlamp.

After proper calibration total results should narrow to 0.1%... 0.2%

| Vehicle | 1L | 1R | 2L | 2R | 3L | 3R | 4L | 4R | 5L | 5R |
|---|---|---|---|---|---|---|---|---|---|---|
| Load condition | | | | | | | | | | |
| 1 | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% | 0,00% |
| Back to 1 | -0,03% | -0,11% | -0,08% | -0,09% | -0,19% | 0,02% | -0,07% | -0,12% | 0,01% | 0,00% |
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| 4 | -0,31% | -0,34% | 0,48% | 0,81% | -0,40% | -0,14% | 0,36% | 0,31% | 0,05% | 0,18% |

# CONCLUSIONS

- EXISTING AUTOMATIC LEVELLING SYSTEMS CAN CONTROL LEVELLING BETTER THAN POSSIBLE TO MEASURE (0.1 %)

- EXISTING AUTOMATIC LEVELLING SYSTEMS WITHOUT SPECIAL PREPARATION CAN CONTROL LEVELLING IN RANGE 0.4%  WITH POTENTIAL POSSIBILITY TO NARROW DOWN TO 0.1 … 0.2 % AFTER CALIBRATION

- THERE IS MUCH BETTER THAN NEEDED FOR PROPOSAL BELOW (0.5%...1.3%) AND THE WORST TESTED CAR CAN FIT THE PROPOSED RANGE

# HOW TO OBTAIN „BOX" CONSENSUS IN GRE

What are the expectations and what can be accepted by Contracting Parties?

- **Automatic levelling** remove most „box" problems resulting from **manual levelling design restriction**

- By proper initial aim and narrow the levelling tolerances the glare will be significantly reduced and the road illumination distance will be increased

- Is it possible to find consensus on the base of laws of physics and real technical feasibility?

- Are there any particular (or hidden) expectations ? What kind of ?

# HOW TO OBTAIN BOX COMPROMISE

Issues raised in IWG SLR:

1. Concerns about increase of glare / expectations to reduce glare
2. Increase the real minimum road illumination distance
3. Freedom to choice the initial aim anywhere inside the box
4. The same initial aim for different vehicle models (if obligatory)
5. Keep the previously proposed box, whether it's good or bad
6. Manufacturers can make good lights so they don't want restrictions
7. Any other?
8. ……………

# RATIONALES FOR „BOX" BOUNDARIES AND SPACE FOR A COMPROMISE

**First:**

**The need to obtain valuable results for long time**
There is no need to compare optimised box with „old box" or „last proposed box" (GRE/2020/8/rev.2) because they use partially artificial lines adapted to presently existing **manual levelling** idea
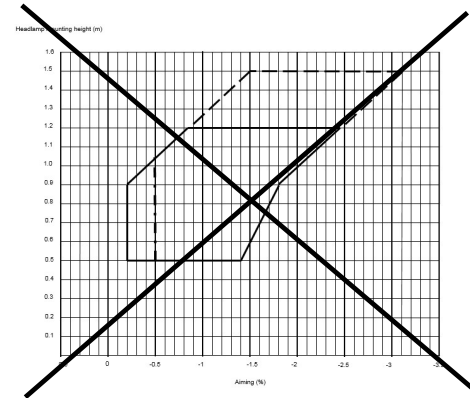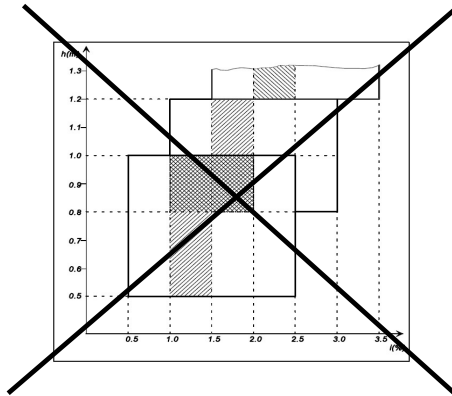


**Second:**

Try to understand what really mean each „box" line in regard to traffic safety and start to think in safety determinants

**Third:**

Take into account that the **automatic levelling** is „different animal" than the **manual levelling** and allow to control the aim with precision even to 0.1% when 0.4% is not a particular challenge. Better then 1.0 % is effortlessly achievable

# SPACE FOR A COMPROMISE – right „box" boundary ROAD ILLUMINATION DISTANCE LINE
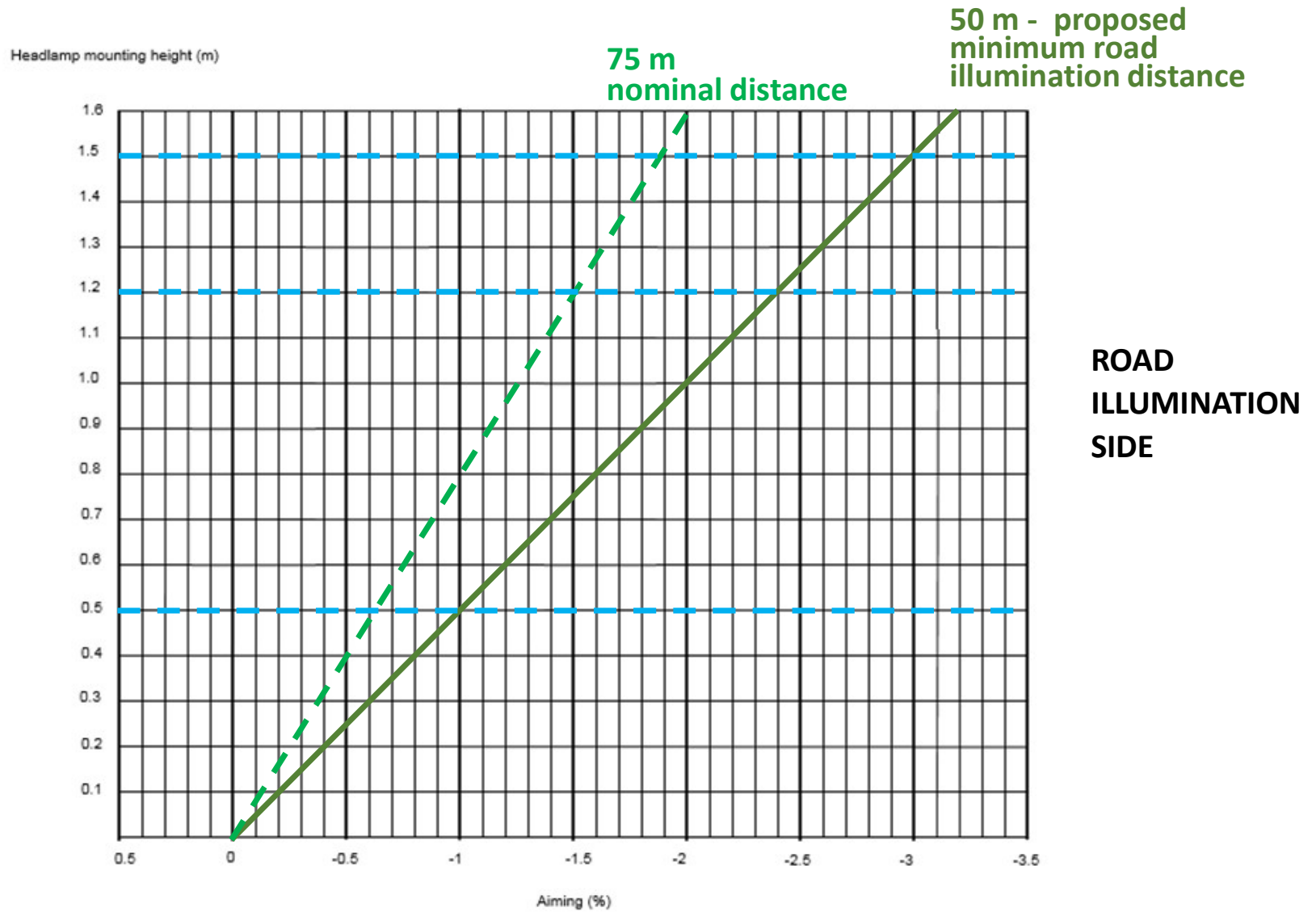
**SPACE FOR A COMPROMISE – ROAD ILLUMINATION DISTANCE**
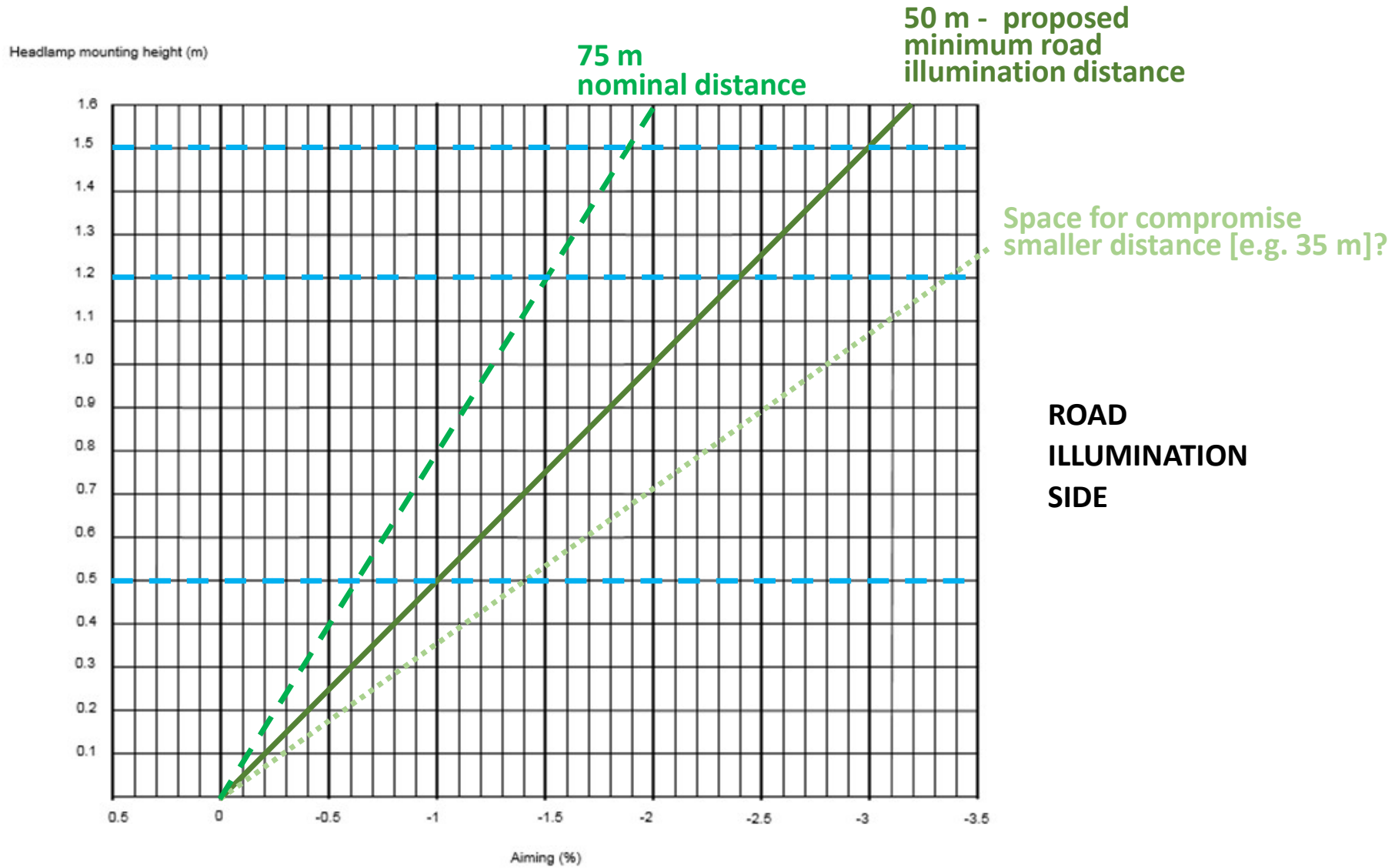
50 m - proposed minimum road illumination distance

75 m nominal distance

Space for compromise smaller distance [e.g. 35 m]?

ROAD ILLUMINATION SIDE

Headlamp mounting height (m)

Aiming (%)

# SPACE FOR A COMPROMISE – GLARE REDUCTION

Headlamp mounting height (m)
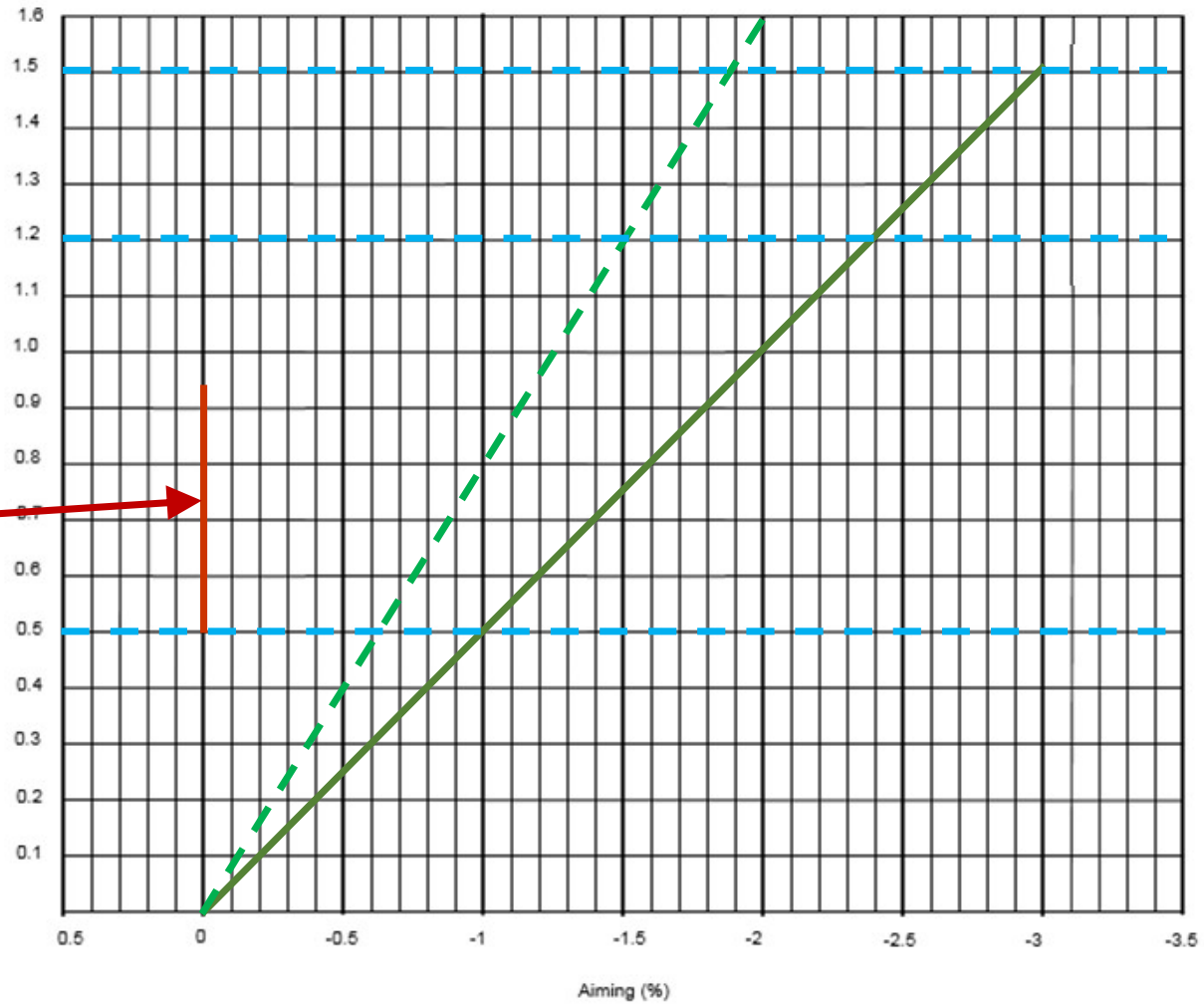
**GLARE SIDE**

**for low mounted headlamps cut-off should be under horizon**

Aiming (%)

# SPACE FOR A COMPROMISE – GLARE REDUCTION

Headlamp mounting height (m)
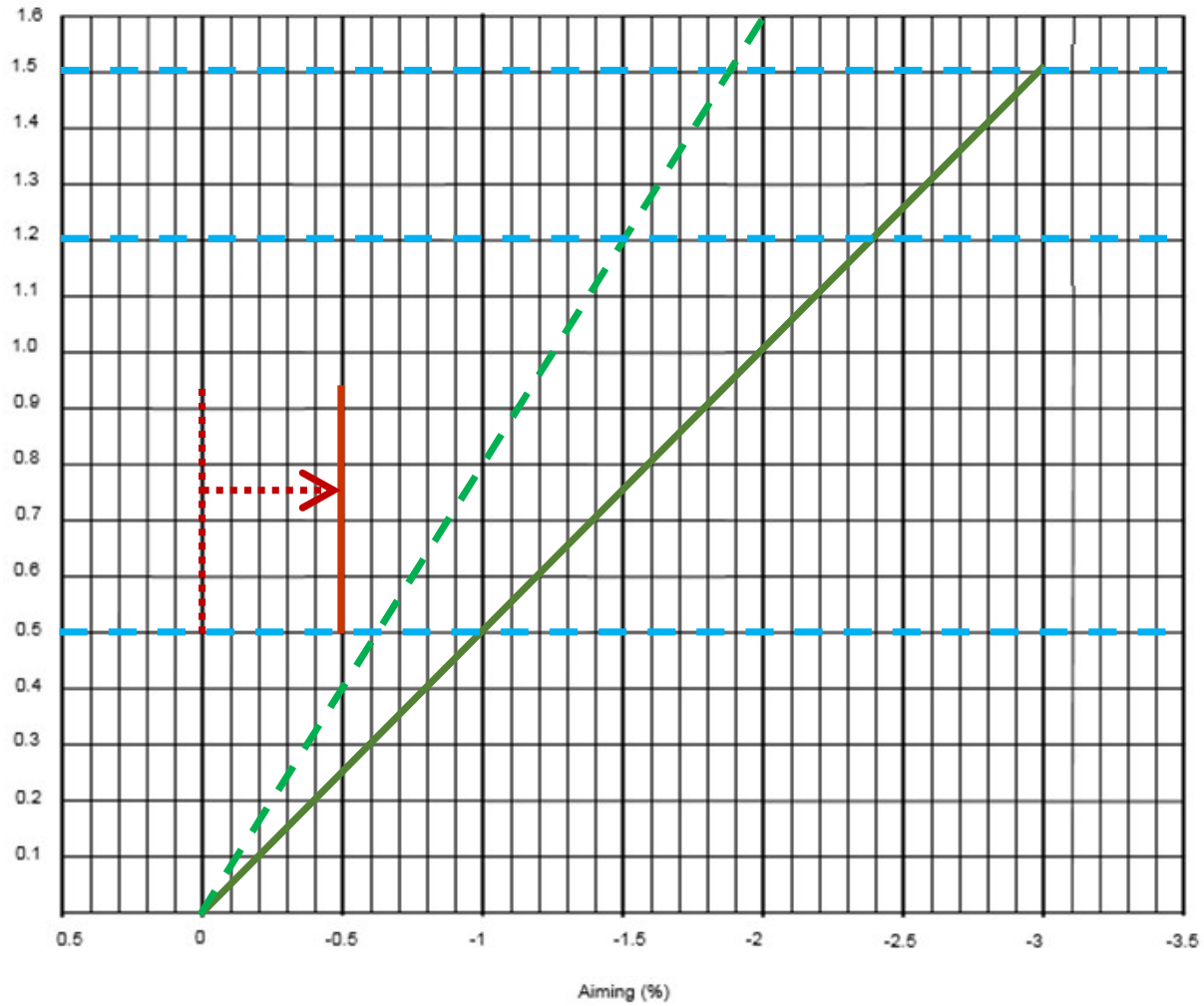
**GLARE SIDE**

for low mounted headlamps
cut-off under horizon

Added safety margin -0.5%

Aiming (%)

# SPACE FOR A COMPROMISE – GLARE REDUCTION

## High mounted headlamps
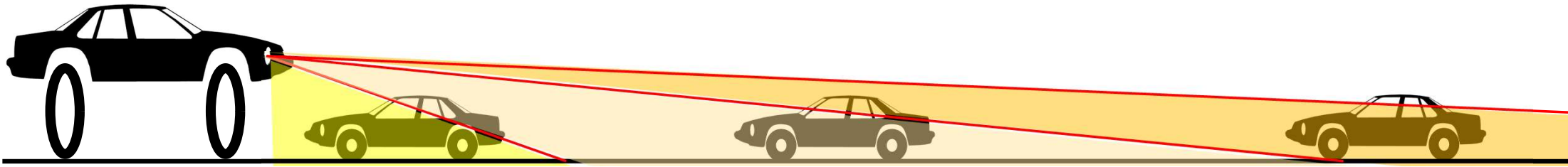


Glare cannot be completely avoided with higher-mounted headlamps

Decision should be make what distance of unavoided glare could be accepted - space for the compromise

# „GLARE LINE" CALCULATION for high mounted headlamps (VGL-08-14 Rev. 1)

$\Delta h$

HEADLAMP
HEIGHGT
[h]

($\approx$0.95 m)

ONCOMING
DRIVER
EYE/MIRROR
HEIGHT $h_{eye}$

$L_{min}$ - DISTANCE OF UNAVOIDABLE GLARE
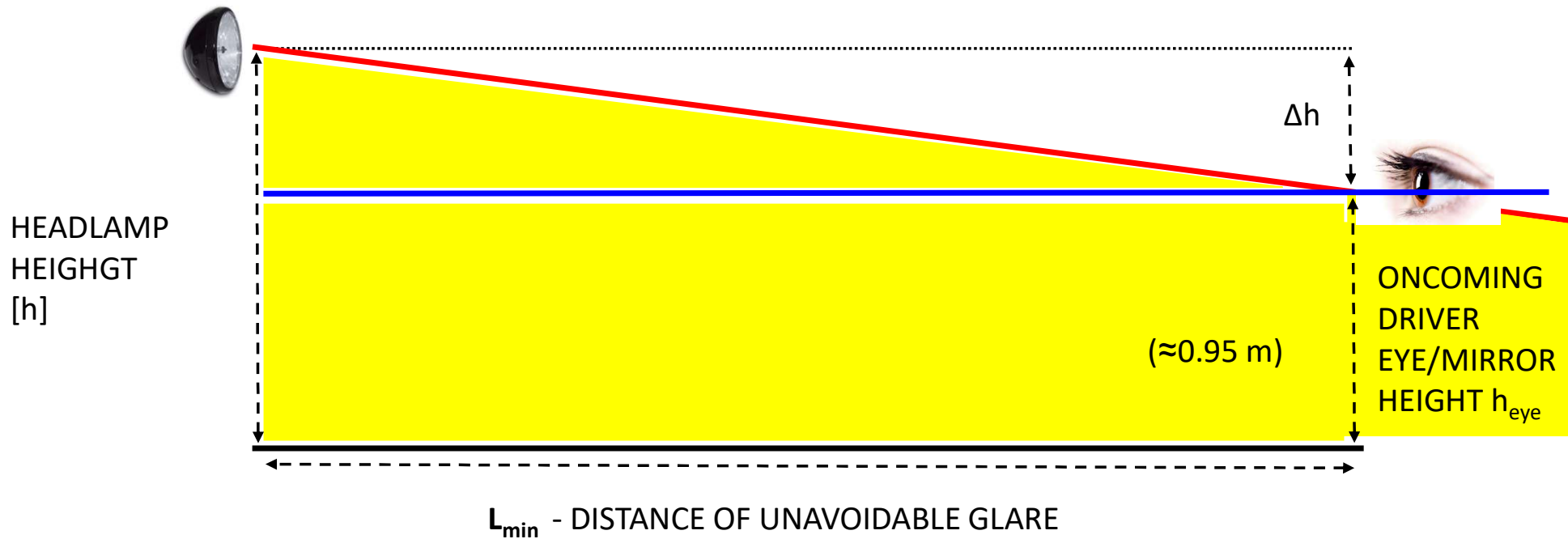
FORMULA:   $I = \Delta h / L_{min}$

I - cut-off inclination

$\Delta h$ - headlamp optical axis height over minimum eye-height

$L_{min}$ - maximum distance beyond the vehicle where glare is accepted (25 m)

# SPACE FOR A COMPROMISE – GLARE REDUCTION
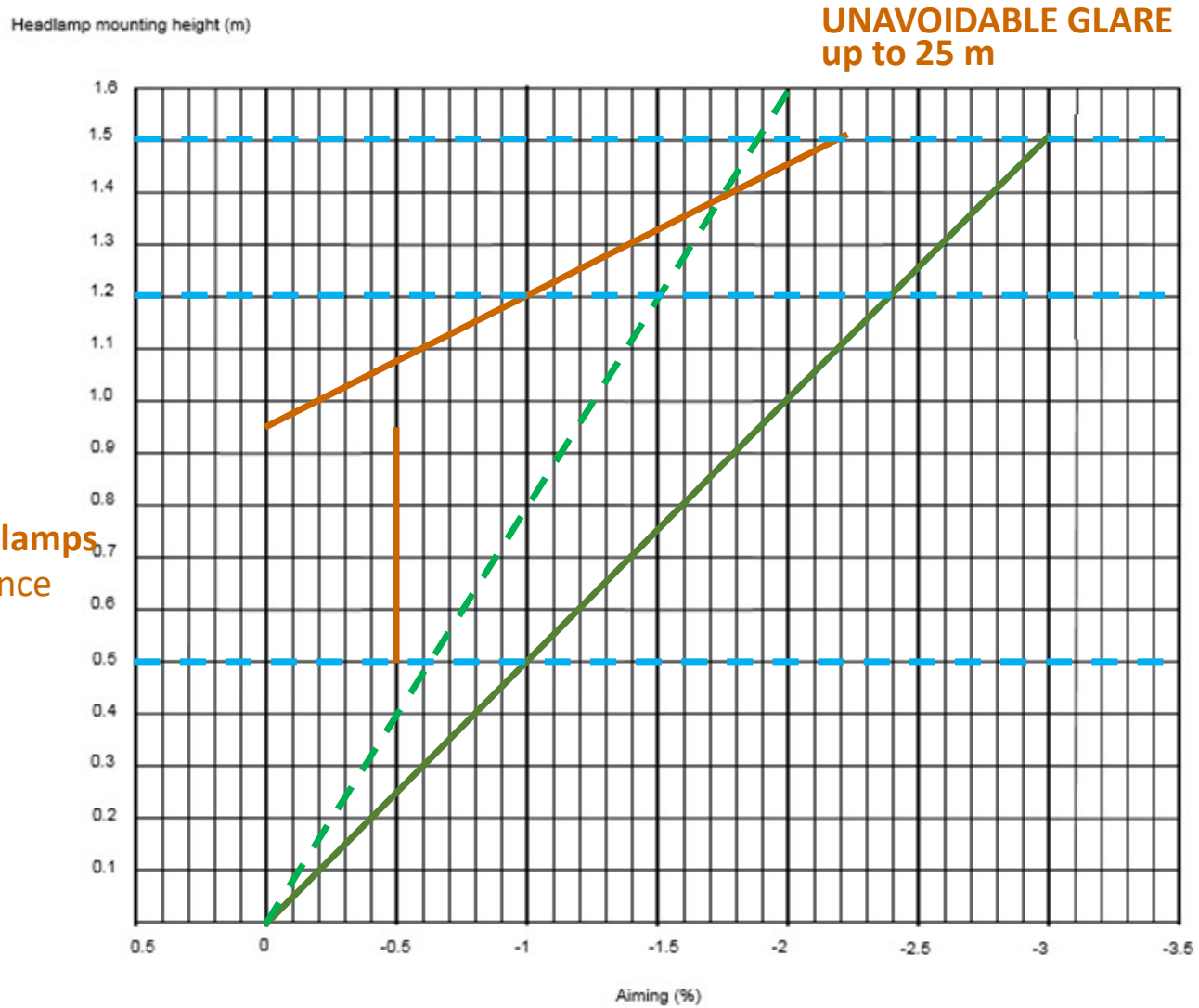


**UNAVOIDABLE GLARE up to 25 m**

**GLARE SIDE**

**for high mounted headlamps** unavoidable glare distance

Headlamp mounting height (m)

Aiming (%)

# SPACE FOR A COMPROMISE – GLARE REDUCTION



**UNAVOIDABLE GLARE up to 25 m**
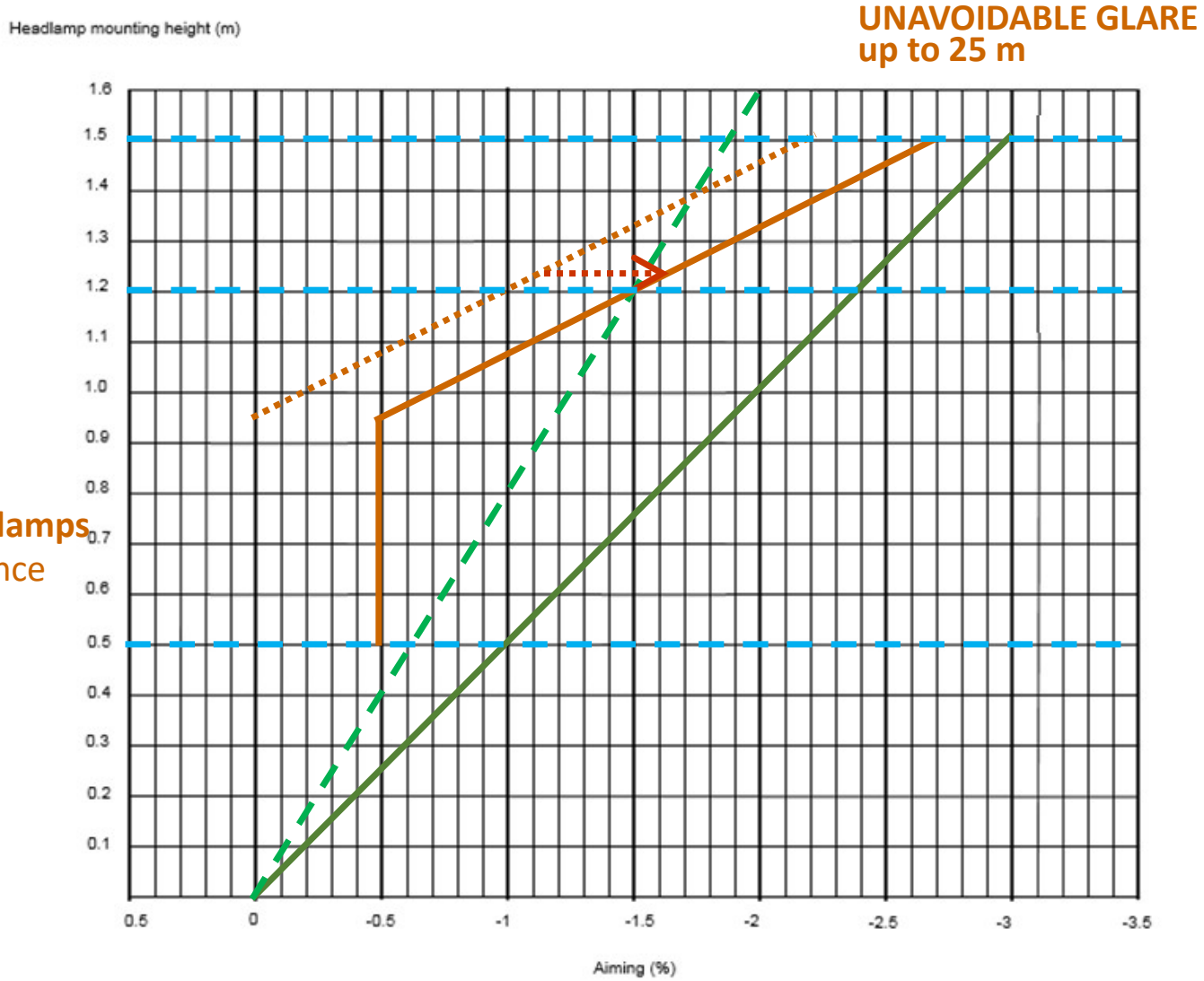
**GLARE SIDE**

**for high mounted headlamps** unavoidable glare distance

Safety margin - 0.5%

# SPACE FOR A COMPROMISE – GLARE REDUCTION



Space for compromise
longer unavoidable glare
up to [50] m ?

unavoidable glare
up to 25 m

Headlamp mounting height (m)

GLARE SIDE

for high mounted headlamps
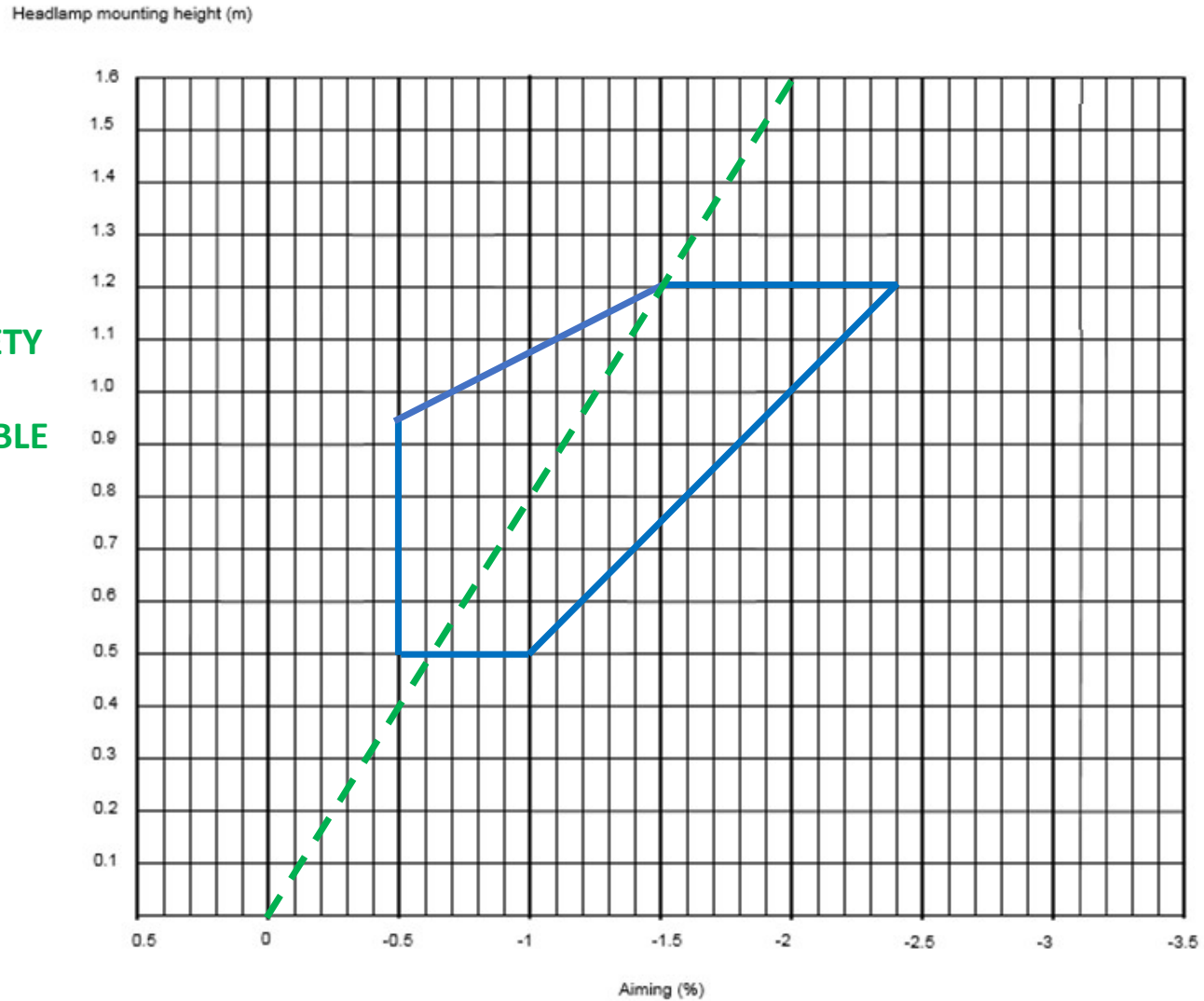unavoidable glare distance

Aiming (%)
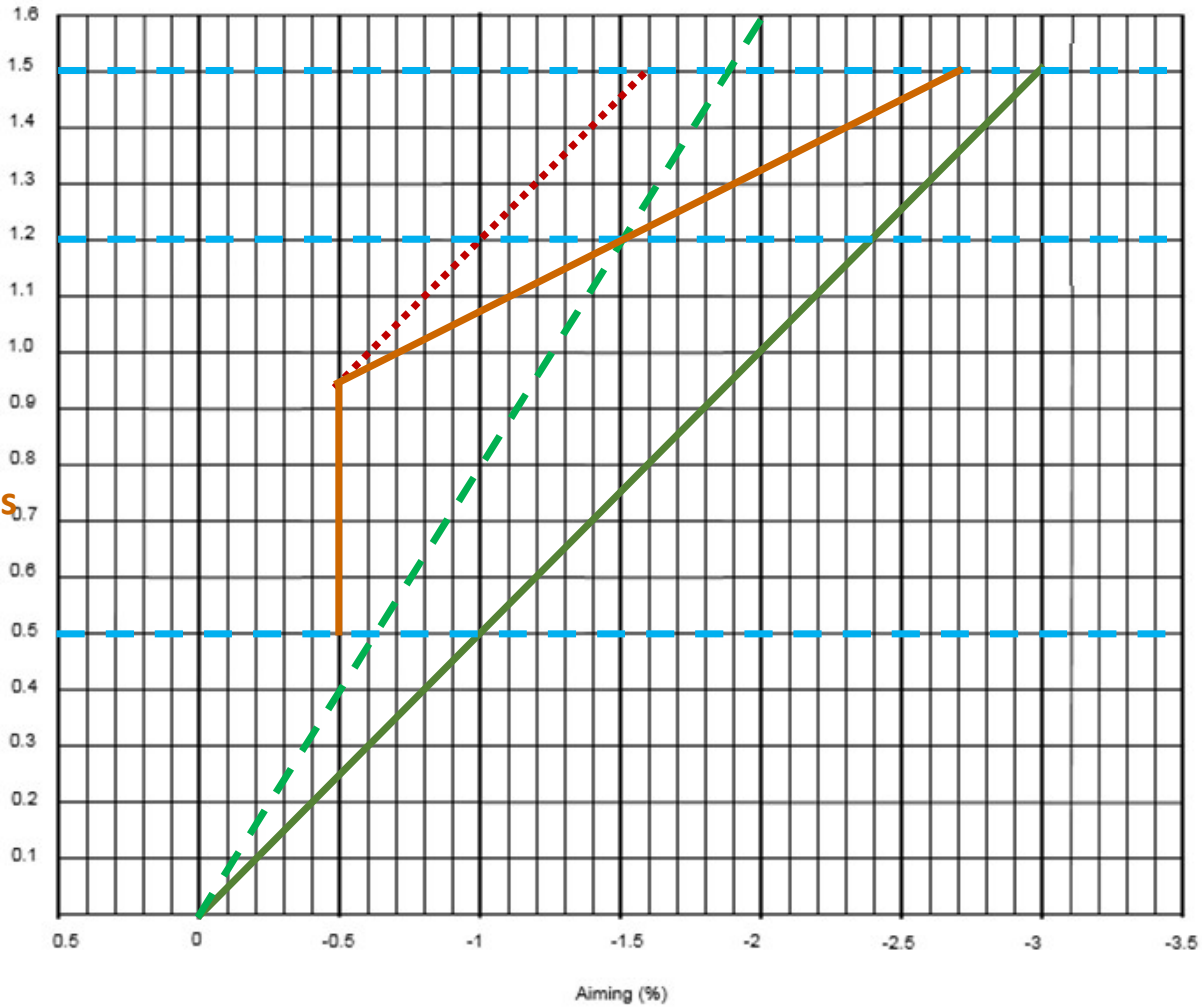
# OPTIMAL BOX FOR SAFETY

Headlamp mounting height (m)



Aiming (%)
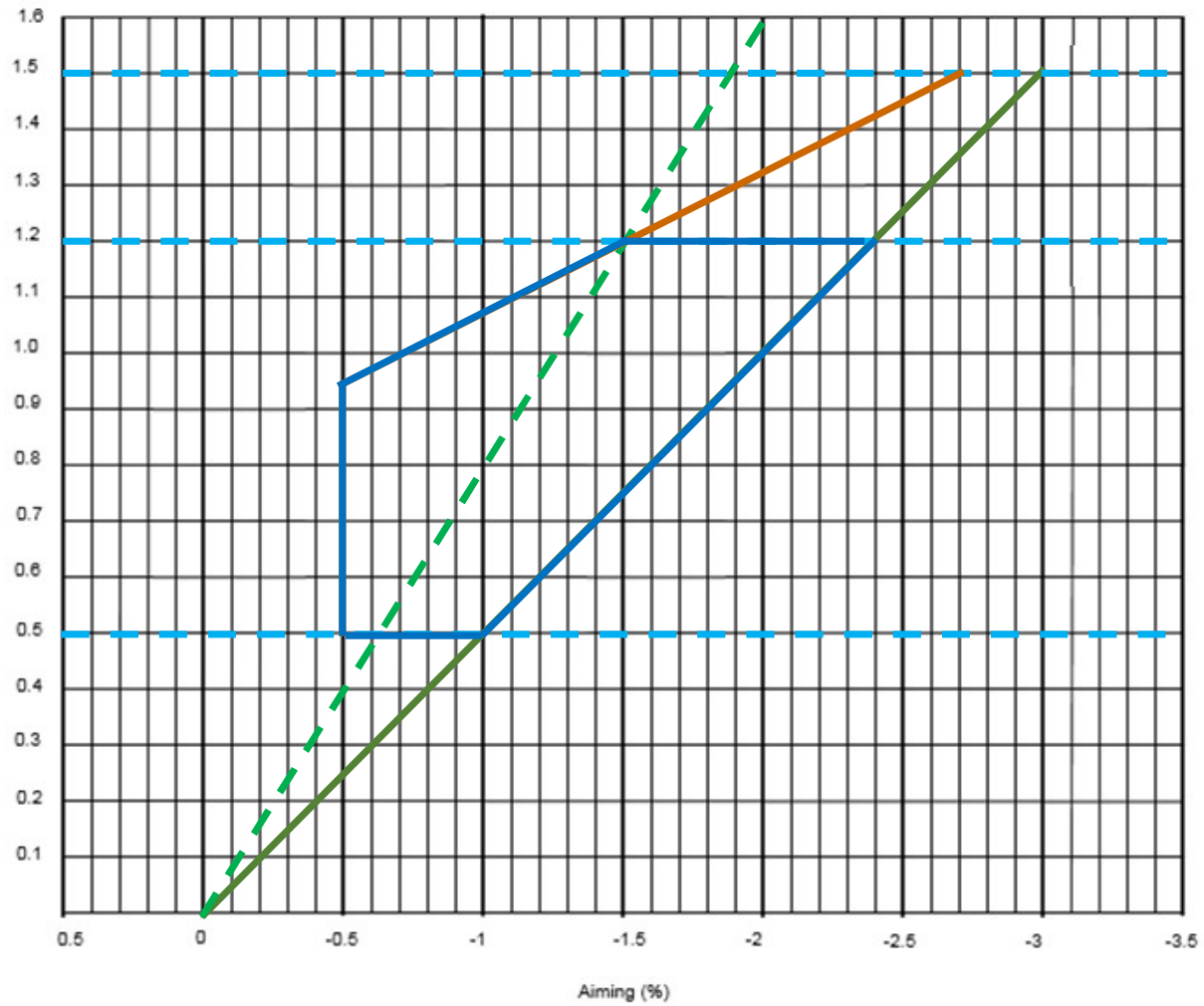
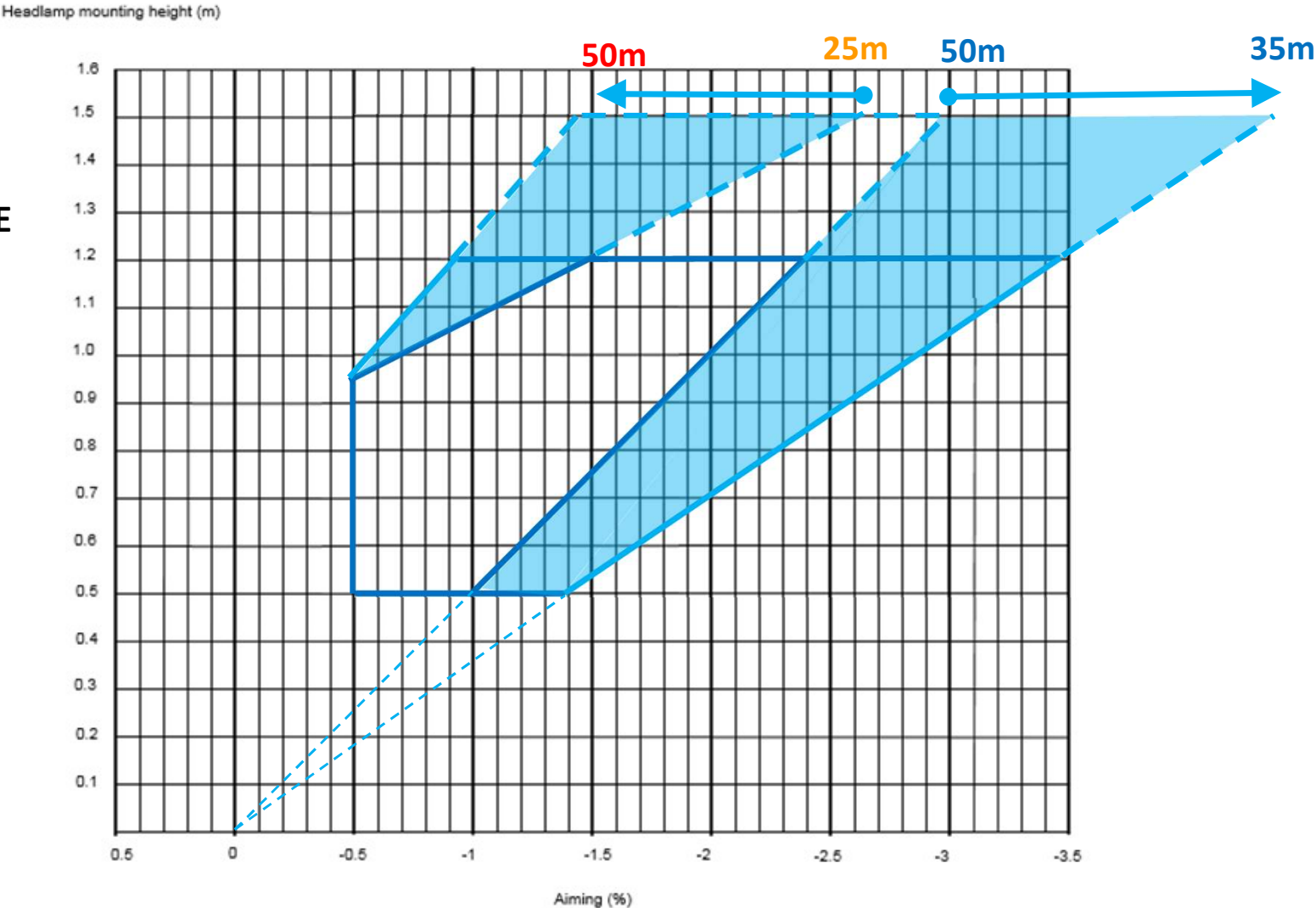# OPTIMAL BOX up to 1.2m MOUNTING HEIGHT – READY TO USE

**CHECK IF THE „BOX":**

- **GUARANTEE THE SAFETY AND**
- **IS TECHNICALLY FEASIBLE**

Headlamp mounting height (m)



Aiming (%)
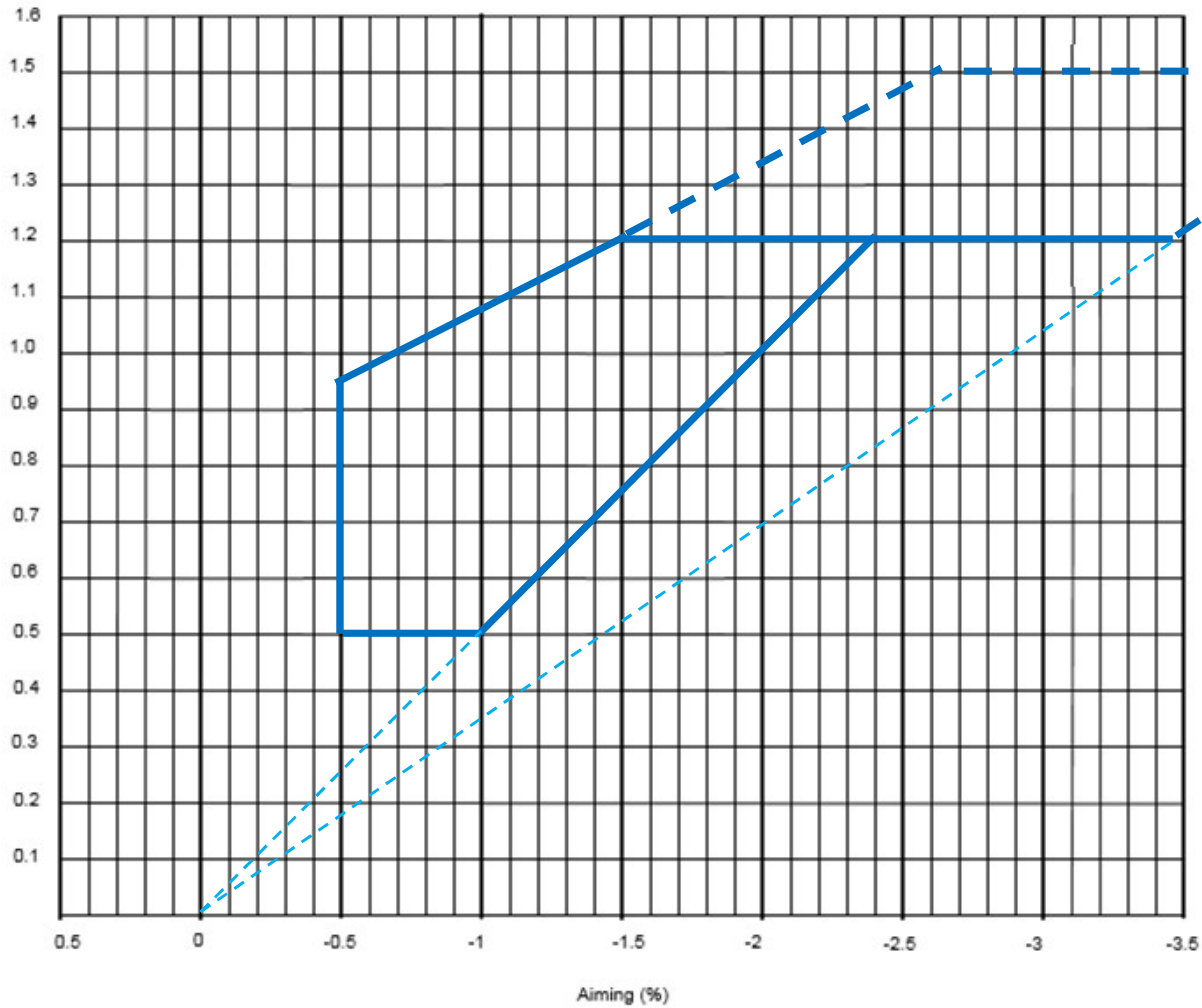
**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# SPACE FOR A COMPROMISE - IF REALLY NEEDED?

**THE COMPROMISE SHOULD BE EXPRESSED IN METERS ON THE ROAD**

# HIGHER MOUNTED HEADLAMPS  (OFF-ROAD VEHICLES)



Headlamp mounting height (m)

Aiming (%)

For higher mounted headlamps (off-road) is higher glare risk but because of usual lower speed the road illumination distance can be reduced to [35]m giving more space for manual leveling up to 2.0%

**INITIAL AIM – fixed or free?**


- **FIXED IN RELATION TO THE HEIGHT** is needed when „box" is defined arbitrary in separation from the laws of physics
     **ADVANTAGE:** No need to require initial aim for vehicle type (no label)

- **CAN BE FREE INSIDE THE BOX** when box truly control road illumination and glare but require do be assigned to the vehicle model
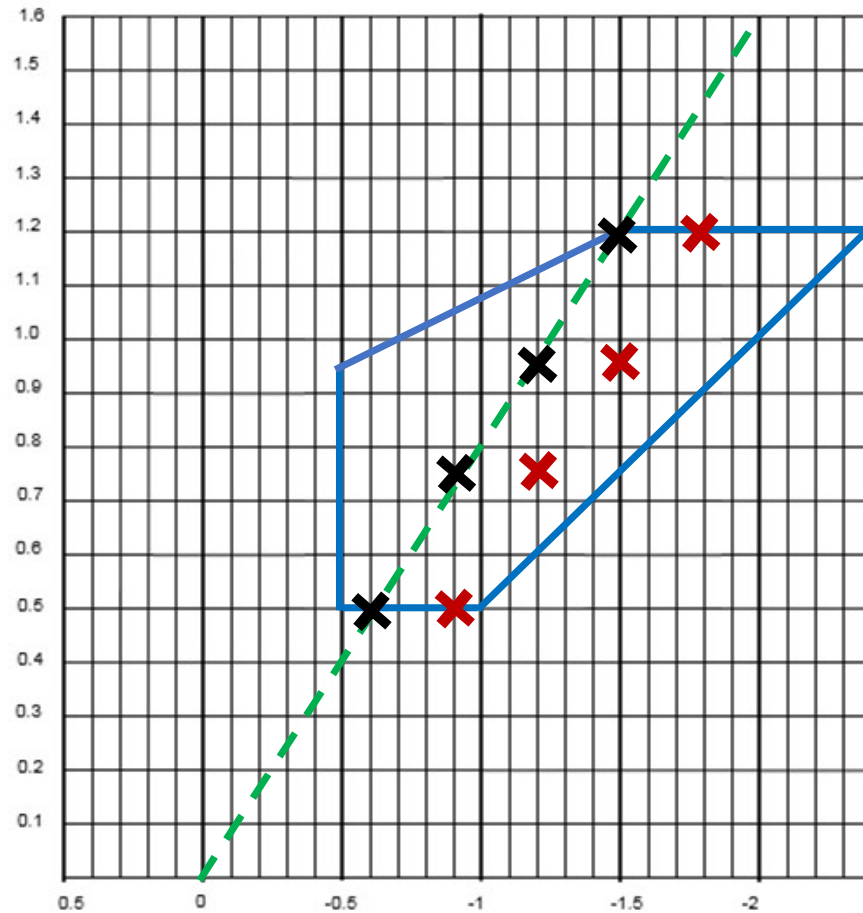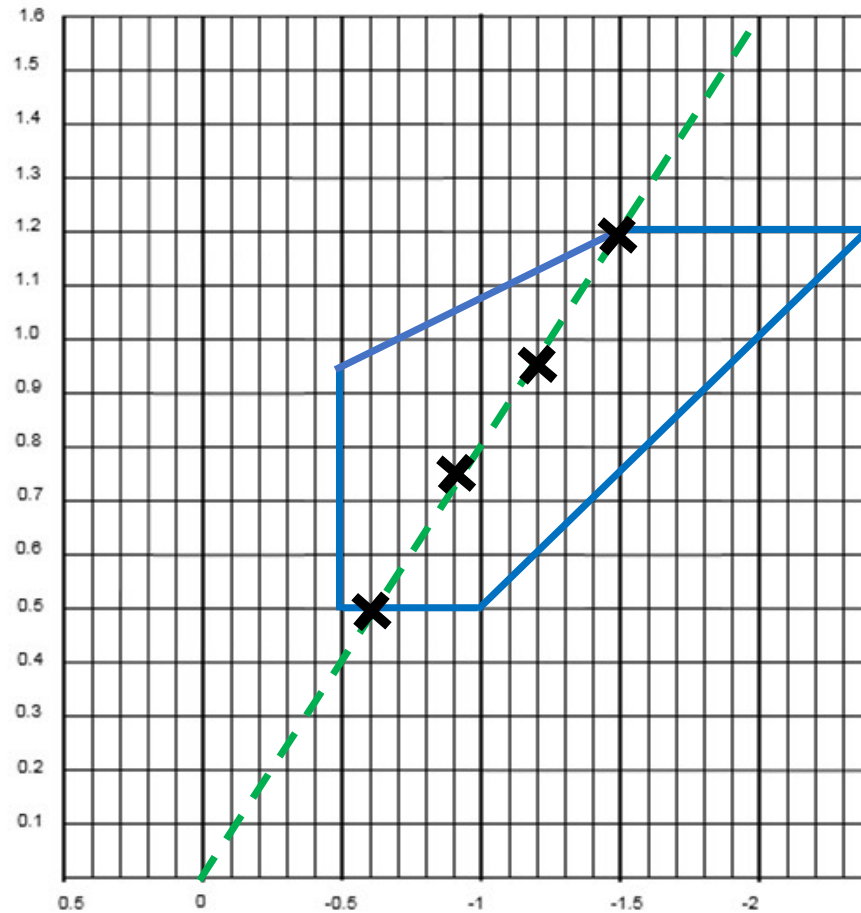
# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITHOUT CALIBRATION (AS IT IS)**

| Vehicle | 1L | 1R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | -0,31% | -0,31% |
| 3 | -0,32% | -0,32% |
| 4 | -0,31% | -0,34% |



Headlamp mounting height (m)

**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITH PROPER CALIBRATION**

| Vehicle | 1L | 1R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | 0,00% | 0,00% |
| 3 | 0,00% | 0,00% |
| 4 | 0,00% | 0,00% |

**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**
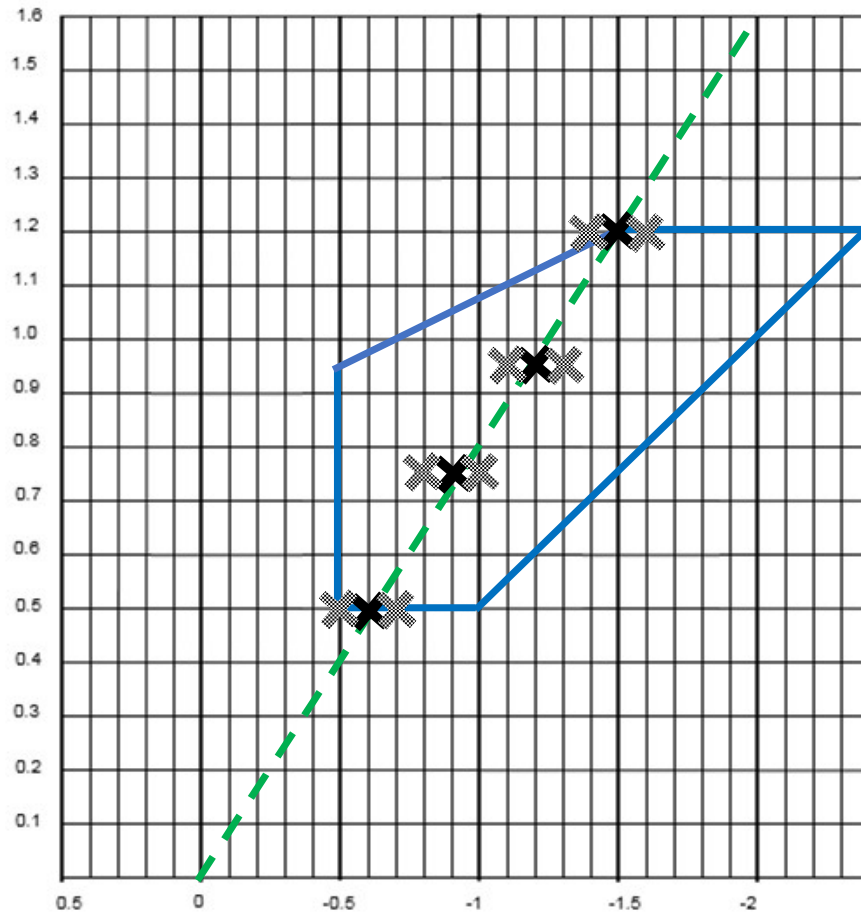
Headlamp mounting height (m)

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITH CALIBRATION MEASUREMENTS UNCERTAINTY ADDED**

| Vehicle | 1L | 1R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | ±0,10% | ±0,10% |
| 3 | ±0,10% | ±0,10% |
| 4 | ±0,10% | ±0,10% |

**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**
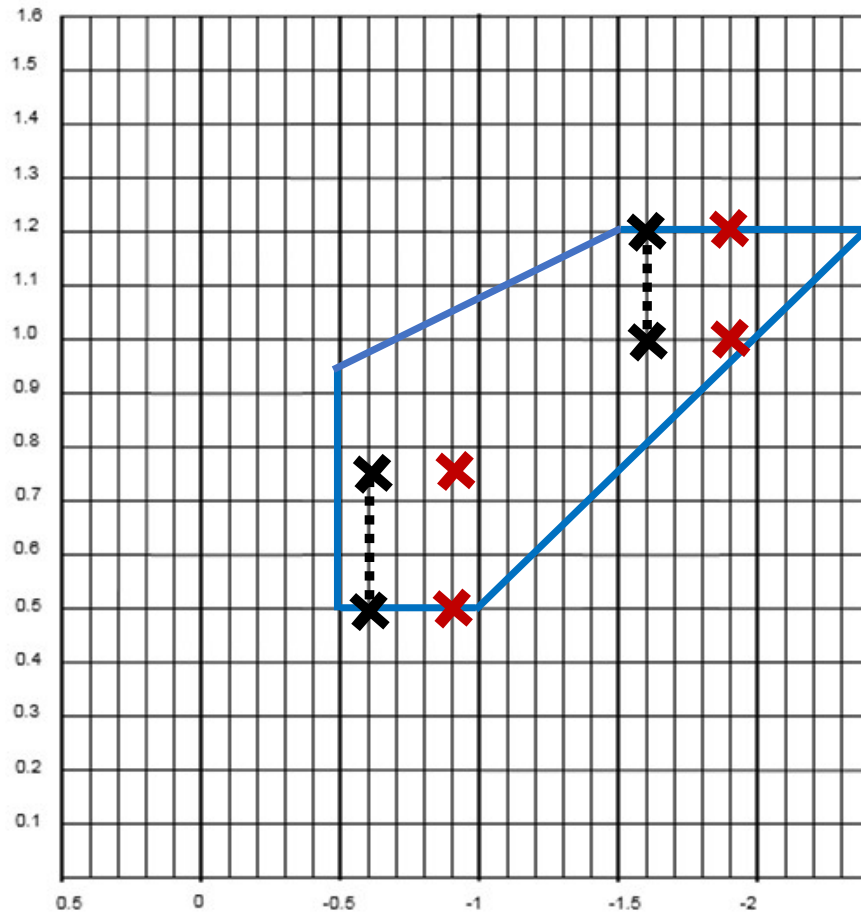


Headlamp mounting height (m)

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**FREE INITIAL AIM**
**- INITIAL AIM VALUE**
**ON THE VEHICLLE**

**WITHOUT CALIBRATION**
**(AS IT IS)**

| Vehicle | 1L | 1R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | -0,31% | -0,31% |
| 3 | -0,32% | -0,32% |
| 4 | -0,31% | -0,34% |

Headlamp mounting height (m)

**SPACE FOR**
**LEVELLING FROM**
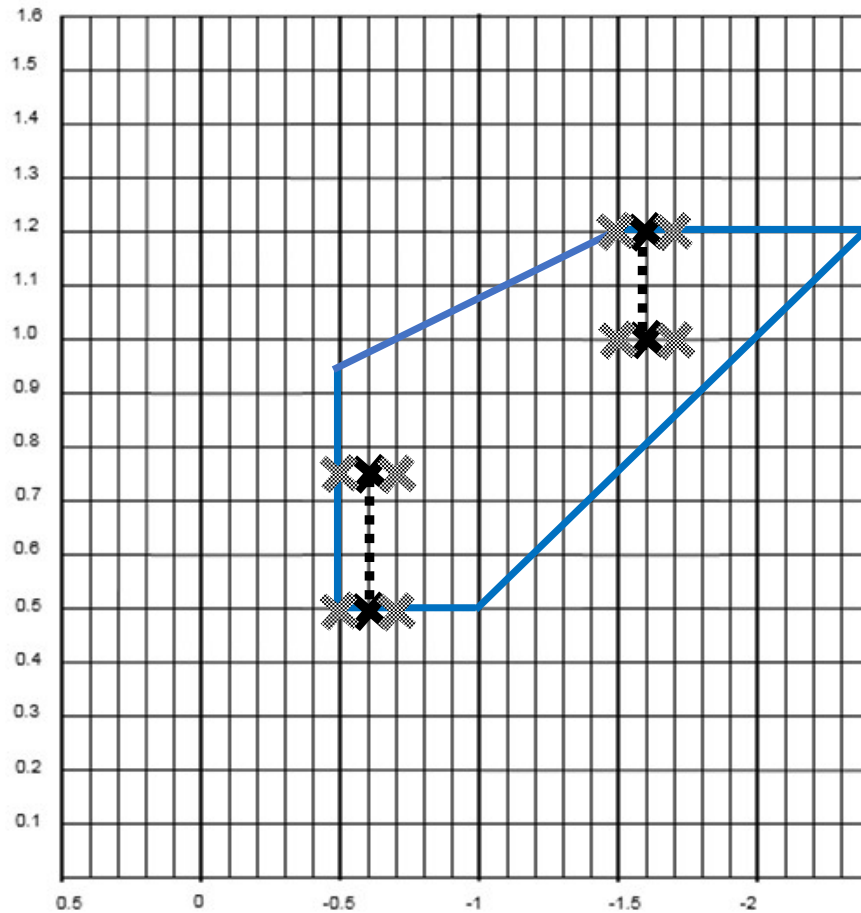**0.5% TO 1.3%**
**DEPENDING ON**
**MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**FR- INITIAL AIM VALUE ON THE VEHICLLE**

**EE INITIAL AIM**

**WITH CALIBRATION MEASUREMENTS UNCERTAINTY ADDED**

| Vehicle | 1L | 1R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | -0,31% | -0,31% |
| 3 | -0,32% | -0,32% |
| 4 | -0,31% | -0,34% |



Headlamp mounting height (m)

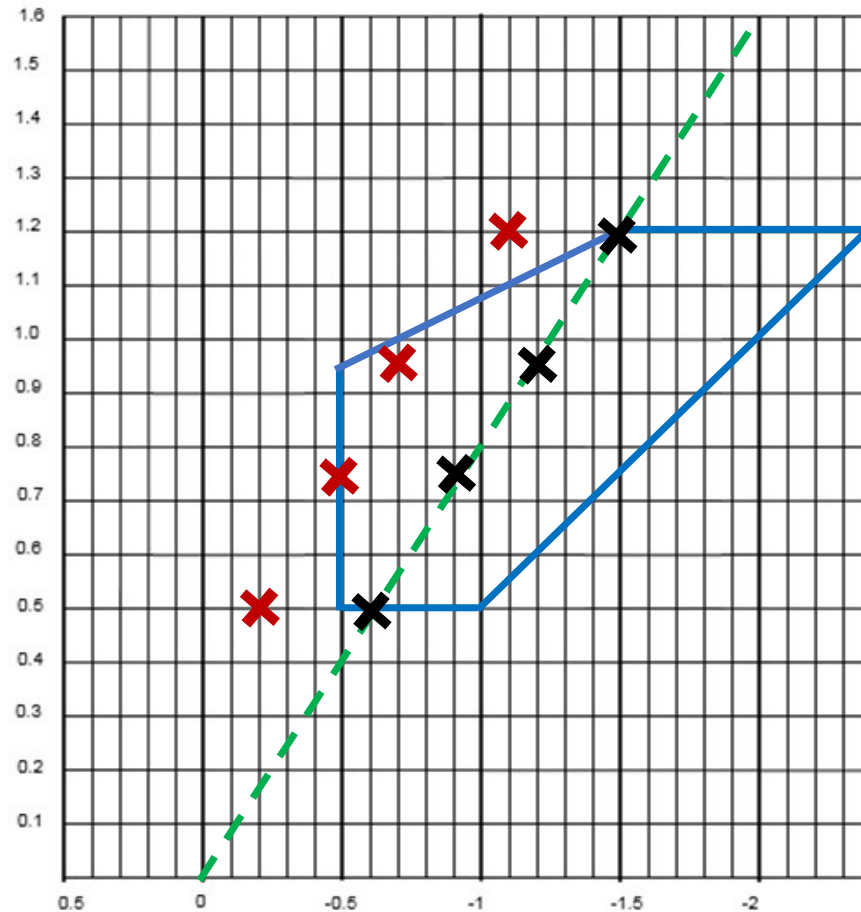**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITHOUT CALIBRATION (AS IT IS)**

| Vehicle | 4L | 4R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | 0,29% | 0,20% |
| 3 | 0,41% | 0,29% |
| 4 | 0,36% | 0,31% |



Headlamp mounting height (m)

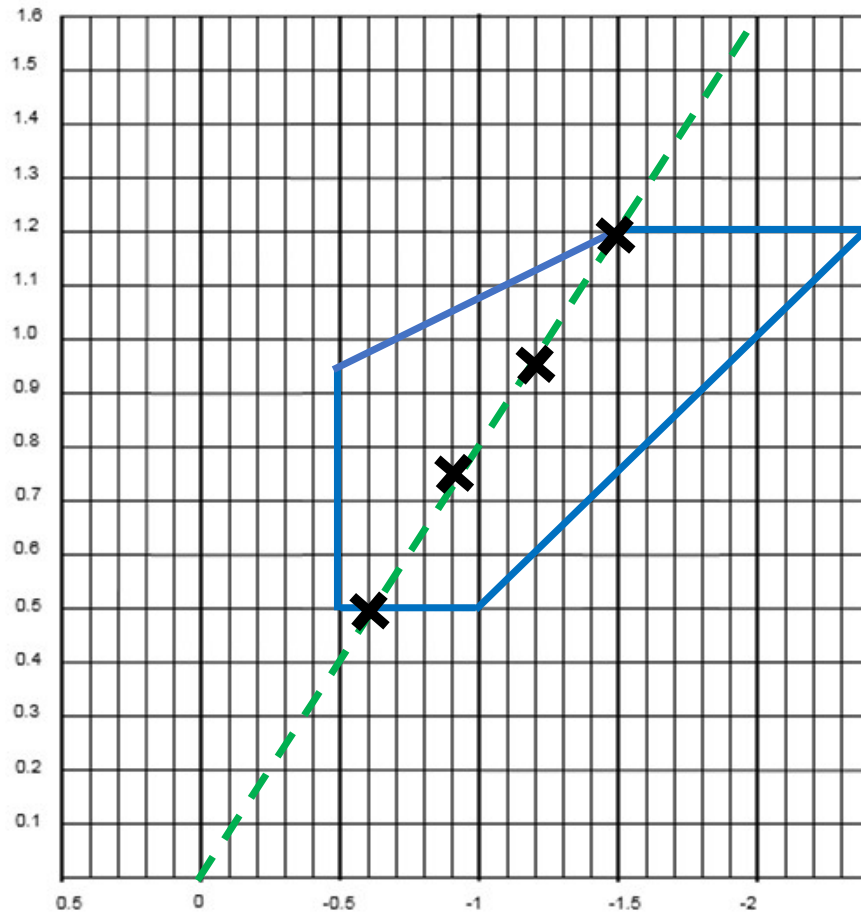**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITH PROPER CALIBRATION**

| Vehicle | 4L | 4R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | 0,00% | 0,00% |
| 3 | 0,00% | 0,00% |
| 4 | 0,00% | 0,00% |



Headlamp mounting height (m)

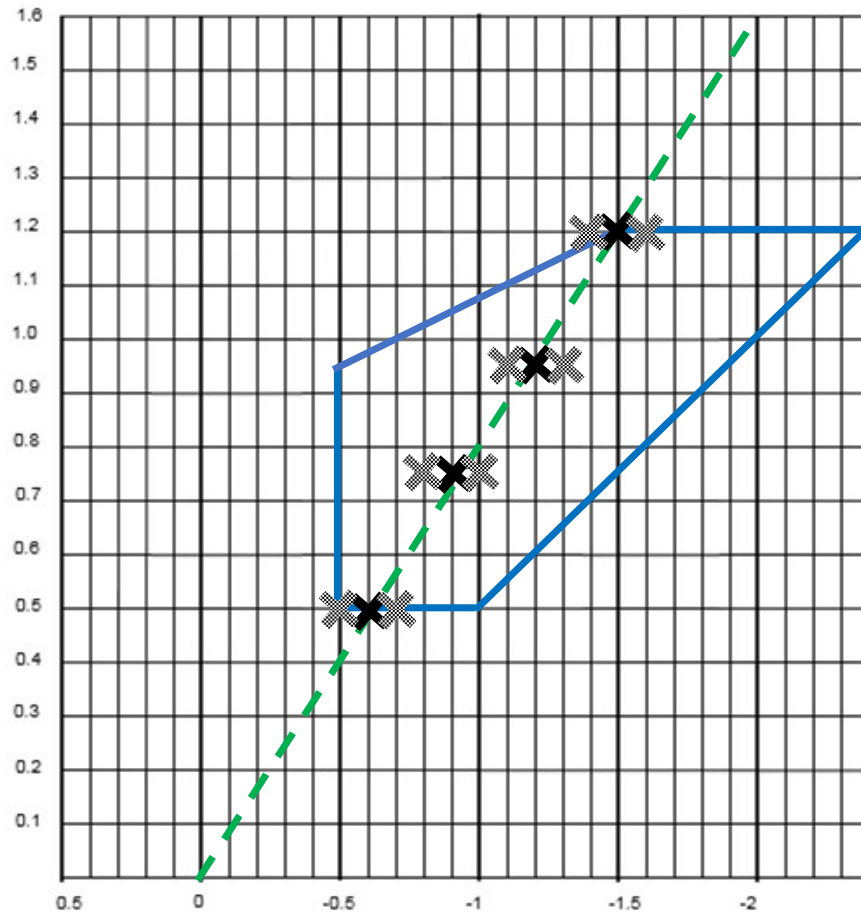**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**INITIAL AIM FIXED IN RELATION TO THE HEIGHT - NO INITIAL AIM VALUE ON THE VEHICLLE**

**WITH CALIBRATION MEASUREMENTS UNCERTAINTY ADDED**

| Vehicle | 4L | 4R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | ±0,10% | ±0,10% |
| 3 | ±0,10% | ±0,10% |
| 4 | ±0,10% | ±0,10% |



Headlamp mounting height (m)

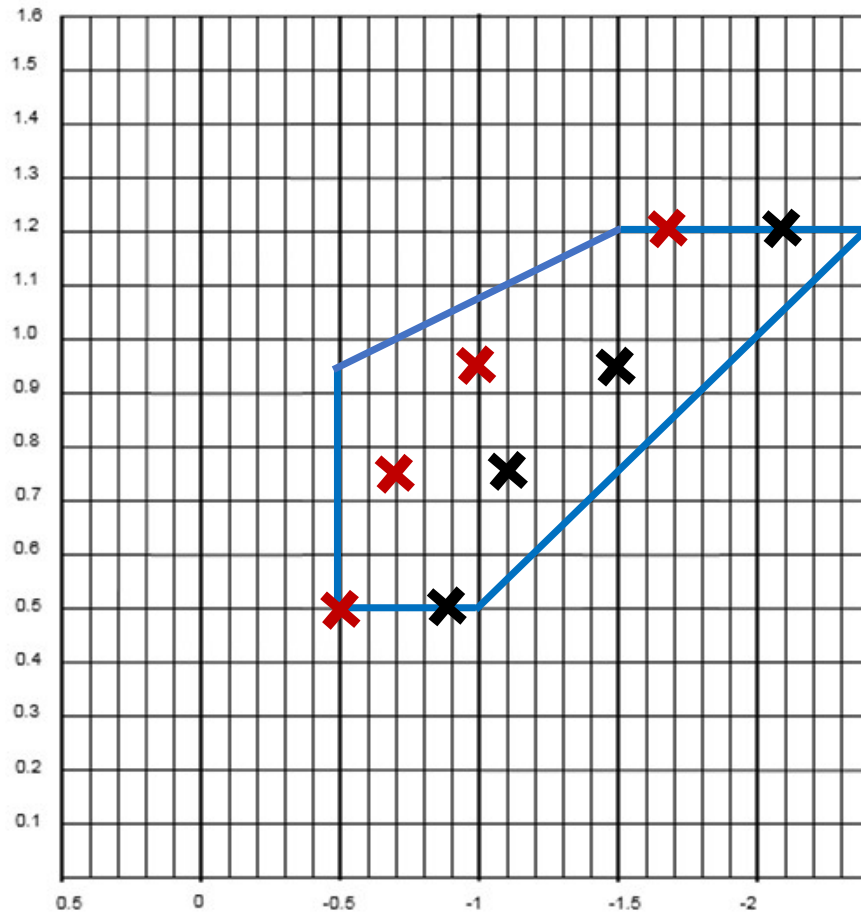**SPACE FOR LEVELLING FROM 0.5% TO 1.3% DEPENDING ON MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**FREE INITIAL AIM**
**- INITIAL AIM VALUE**
**ON THE VEHICLLE**

**WITHOUT CALIBRATION**
**(AS IT IS)**

| Vehicle | 4L | 4R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | 0,29% | 0,20% |
| 3 | 0,41% | 0,29% |
| 4 | 0,36% | 0,31% |

Headlamp mounting height (m)



**SPACE FOR**
**LEVELLING FROM**
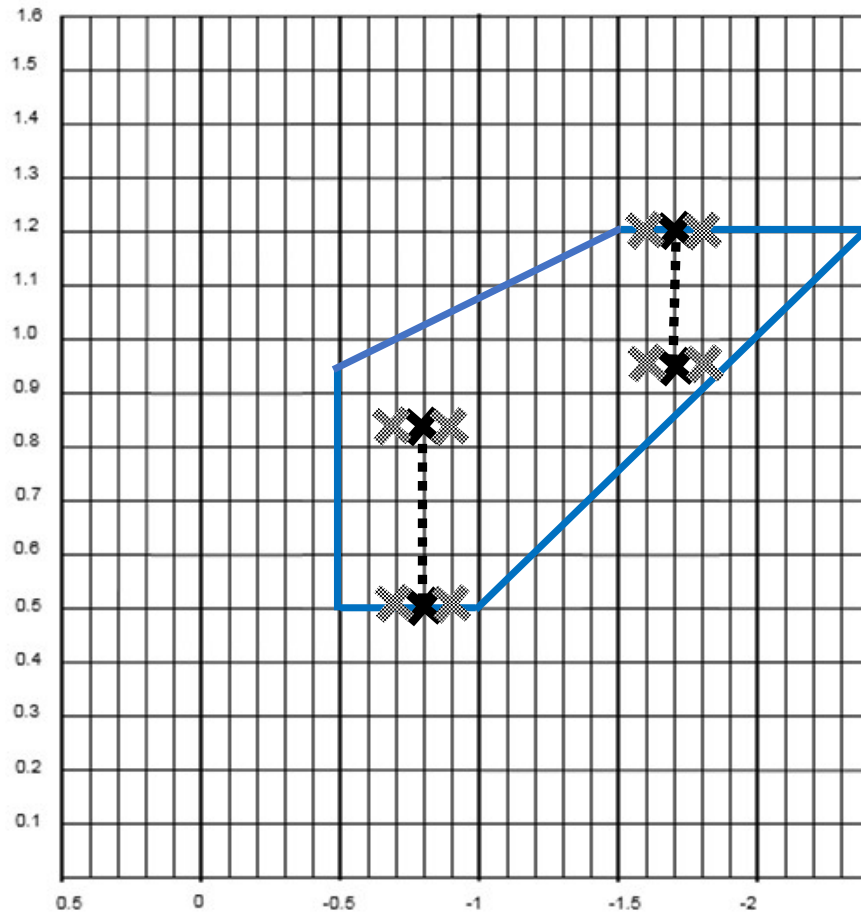**0.5% TO 1.3%**
**DEPENDING ON**
**MOUNTING HEIGHT**

# PROPER UNDERSTANDING TEST RESULTS AND PROPOSED „BOX"

**FREE INITIAL AIM**
**- INITIAL AIM VALUE**
**ON THE VEHICLLE**

**WITH CALIBRATION**
**MEASUREMENTS**
**UNCERTAINTY**
**ADDED**

| Vehicle | 4L | 4R |
|---|---|---|
| Load condition | | |
| 1 | 0,00% | 0,00% |
| 2 | ±0,10% | ±0,10% |
| 3 | ±0,10% | ±0,10% |
| 4 | ±0,10% | ±0,10% |

Headlamp mounting height (m)

**SPACE FOR**
**LEVELLING FROM**
**0.5% TO 1.3%**
**DEPENDING ON**
**MOUNTING HEIGHT**